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ABSTRACT

The purpose of this study was to identify factors responsible for the perceived decline in attitudes toward science observed in an intervention study designed to enhance scientific literacy. The literacy study focuses on a new freshman course in an urban Catholic high school. Negative attitudes toward science were found to be related to the demand characteristics of the scientific literacy course, which emphasized problem solving. Although the course was successful in teaching literacy skills and had a positive effect on general cognitive abilities, there was a sharp decline in attitude toward science between the beginning and end of the course. Factors related to attitude decline are discussed in terms of self-concept, mastery, locus of control and motivation. (TW)

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Learning to Think: A Major Factor in the Decline in Attitude Toward Science

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Abstract

Negative attitudes toward science were found to be related to the demand characteristics of a scientific literacy course which emphasized problem solving. Although the course was successful in teaching literacy skills and had a positive effect on general cognitive abilities there was a sharp decline in attitude toward science between the beginning and end of the course. Factors related to attitude decline are discussed in terms of self-concept, mastery, locus of control and motivation.

INTRODUCTION

The purpose of this study is to identify factors responsible for the decline in attitude toward science observed in an intervention study to enhance scientific literacy (Baker & Piburn, 1985; Baker, Cotterell, LeCavalier, Piburn, 1985). The literacy study consisted of a new curriculum which was taught over a period of one year to the Freshman class of an urban Catholic high school. Data on attitude toward science, personality and cognitive ability were collected at the beginning and end of the school year. The students were also tested periodically on the concepts and processes that were part of the literacy course. Teachers were interviewed to obtain their perceptions of the effect of the course on the students and students were asked to evaluate the course, teaching methods, and teachers.

Although the intervention was successful in teaching literacy skills and also had a positive effect on cognitive ability (Baker & Piburn, 1985; Baker, Cotterell, LeCavalier, Piburn, 1985) there was a marked decline in the students attitude toward science as measured by the School Attitude Measure (Wick & Smith, 1980) (Table 1).

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insert Table 1 about here

This instrument has five scales: (a) Motivation, (b) Self-concept 1, (c) Self-concept 2, (d) Control, (e) Mastery. Motivation assess the impact that past experiences have had on the students' desire for school work, as well as the value they place on it, relevance, and whether they wish to pursue school

work further. The two academic self-concept scales measure performance based self-concept (Self-concept 1), an assessment of an individual's confidence in his or her abilities and a reference based self-concept (Self-concept 2), assessing students' perceptions of how others see them. The items in Control are a measure of a student's perceived influence over relevant school events and measures locus of control. Fro the Mastery scale students are asked to give an honest evaluation of their actual school skills. This test has a reliability of .95 for the five scales. In responding to these scales the students were instructed to limited their responses to how they felt about science. For every scale except reference based self-concept (Self-concept 2) there was a decline in attitude at the $p<.00$ level between pre and post-test scores.

REVIEW OF THE LITERATURE

The area of attitude toward science is of considerable interest to science educators because most of us believe that positive attitudes influence a student's decision to study or pursue a career in science. The National Assessment of educational Progress (National Assessment of Educational Progress, 1979) indicates that 31% of high school students and 21% of junior high students find science often or always boring. Researchers have investigated home, school, social, economic, personality, and cognitive factors in order to better understand why so few students like science. Since this study is concerned with the effects of a literacy curriculum on attitude the following review will concentrate on school-based factors.

A bewildering range of school related conditions have been investigated in relation to attitude toward science. Hamrick and Harty (1987) found that

the sequence and structure of course material was related to attitudes among 6th grade students. However, matching instructional strategies with student characteristics was found to have only a limited influence on students' attitude toward science (Trout & Crawley, 1985).

McMillan and May (1979) and Baker (1985) found that science achievement as reflected by grades did not influence whether middle school students liked science. Students receiving poor grades could have a more positive attitude than those with good grades. Others have found a positive relationship between grades and attitude (Steinkamp & Maehr, 1983). Ahlegren and Walberg (1973) found that a positive attitude toward science was the result of an environment lower in intellectual demands. Anderson (1970), Walberg (1969), and Fraser and Fisher (1982) all found that student perceptions of the classroom environment are related to attitudes toward science.

In addition attitudes vary by school location; urban or rural (Lin & Crawley, 1975), grade in school, and sex of the child as a mediating factor of school science experiences (Rennie & Parker, 1987).

As the variety of studies on the subject of attitude indicate there are many school-based factors that influence a students' attitudes toward science. This makes it difficult to make generalizable statements useful for curriculum developers and teachers alike. In the case of the scientific literacy course many of the factors previously cited such as environment and grades were investigated as well as those factors unique to the course.

SAMPLE

The sample consisted of 83 male and female 9th grade students from intact classrooms chosen from the Freshman class of a large urban Catholic high

school. The Freshman class was heterogeneous in respect of ability and racial composition and had approximately equal numbers of male and female students. All Freshman were required to take the literacy course which was taught by three experienced male science teachers.

At the beginning of the school year the students were randomly assigned to one of the three teachers. The teachers moved at the same pace through the materials and held weekly meetings to discuss their problems and collaborate on the use of materials and teaching methods. One of the three teachers' classes was randomly chosen to respond to the course evaluation. This subsample was approximately 25% of the students who had taken the literacy course.

PROCEDURE

The intervention consisted of a series of skills taught in a developmental sequence from easiest to most dificult. The skills were introduced using generic materials such as buttons for classification. Students then received content lessons that required the use of the skill. Students who were successful in applying the skill in this context were given additional enrichment activities. Lessons also included discussions and activities about the nature and limitations of science. Lessons were hands on problem solving activities and students did not have a traditional text or laboratory book. The students were tested at the end of each skill unit.

Monitoring the students' progress and attending teacher meetings led to the conclusion that a random sample of intact classes would provide the evaluation data needed without subjecting the entire Freshman class to yet another round of testing. A smaller sample was also chosen because of the in-

depth analysis required to understand the relationship of the Likert scale data to the narrative responses.

The evaluation instrument consisted of both Likert scale and open response questions. The scale ranged from 1 to 5 with 1 being the most negative and 5 the most positive response. Each question also had a space for comments. Students were also asked to report their expected overall GPA and their expected grade in the science class. A numerical value of 1 was given to the letter grade of A, 2 for B, 3 for C, 4 for D, and 5 for E. The open response questions asked students to comment on the strengths and weaknesses of the teacher and ways in which the class might be improved or enhanced. The questions were selected to assess specific aspects of the course, especially the problem solving literacy skills approach, and provide insights into the decline in attitudes. In total there were 20 items (table 2).

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insert table 2 about here

Means and standard deviations were calculated for each of the items (Table 3) as well as the frequency of responses for each increment on the Likert scale.

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insert Table 3 about here

RESULTS

Likert Scale

An examination of the mean scores indicate that the group response to most items was very close to 3, a neutral response on a 5 point scale. Exceptions were that the students thought the course stimulated thinking (X=4.0), teacher ratings (x=2.6), liking the course material (x=2.7), how conducive the environment was for learning (x=3.5) and fairness of grading (x=4.0). The students also expected to get the same grade in the course, B+, as their grade point average in school (x=2.18, x=2.19). The standard deviations for the mean scores for the items were close to or greater than 1 in every case. Clearly a score close to 3 on a 5 point scale with a large standard deviation indicates that many students hold strongly different opinions about the quality of this course.

When the responses are divided into three groups, above, below and at response 3, strongly negative feelings (responses 1 and 2) range from 13% to 40%. Strongly positive feelings (responses 4 and 5) range from 19.5% to 72.3%. Neutral feelings range from 14.5% to 56.5 % (Table 4).

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insert Table 4 about here

Question 1," Does he [the teacher] stimulate thinking?", received the highest positive rating. Seventy-two percent of the students rated this item a 4 or 5. Student comments for this item were limited. One student thought the class was "Sometimes too stimulating." Others felt that "The course was very interesting and informative and I learned a lot." or it was a "Very

interesting way of keeping students' attention. He tells you where you will need this info. It made the class seem important."

fifty percent responded to question 2 positively, "Does he [the teacher] put things across in an interesting way?" but 21.9% felt that the teacher did not. Several students said that it was a boring class. Others repeated this theme saying "He tries but its pretty boring." or "Doing the same things all year makes class boring. Do funny things never." One student said "Put more fun into it." Another said "Get fun materials for class."

From the comments of the satisfied students you would think they were in another class. They said "Makes you think about things.", "He gives good fun lectures.", or "Keeps your attention.", "He makes it fun." Other satisfied students said "made the class interesting.", " I always want to listen to him. I like learning while he teaches."

Question 3, "Considering everything how would you rate this teacher?" had the same pattern of responses (48.7% positive and 22.0% negative). This question also received the greatest number of comments from the students which were either strongly positive or strongly negative. The negative students said that he was moody, mean, quick to anger, yelled at the students, was inpatient, intolerant and likely to get upset when students didn't understand the material. This led to many students expressing fear and dislike of science. Students said:

> When he yells he scares me away from science so that I don't like it anymore. If you don't understand something he scares you to death until you do. He can get uptight teaching and really scare the students. Hollering and making you feel small and stupid. He talks too harshly. He

is so hard that when we loose what's going on we ask to explain it again he is short tempered. He doesn't care when he upsets someone to the point of tears. He yells a lot when we don't understand something.

An insightful student seems to have captured the essence of the problem when he/she said "He has a short temper for us Freshman."

The students who made positive comments focused on good teaching, organization, subject matter knowledge, and in contrast to those who rated the teacher negatively, kindness, helpfulness and understanding. These students said:

Very interested in the subject. Very intelligent and knows what he is talking about. Knows what he is talking about and can explain it well. Knows everything on the subject he is teaching. Strength is organization. He is always in control of the class. He's a good teacher. He likes teaching. Tries to do the best job he can.

Referring to his interpersonal skills these students said:

He answers questions and makes sure kids know everything he teaches. Kindness, caring, helping people when they're stuck. Works very well with students and understands them well. Really tries to help us. [He] sticks with students. He's fun. Cool, great guy.

It seems as if there are two different teachers in the same room.

Almost 28% of the students found the course objectives unclear, while 42.7% thought they were very clear. Comments were "Confusing.", "Give us an outline.", "Get a definite plan and make this clear to the students." and "Sometimes I wouldn't know why you do things." Not finding the objectives

clear may be part of the overall dislike of the course seen in the pattern of negative evaluations on the questionnaire (Table 4).

Question 5, "Is the amount of work required appropriate for the amount of credit received?" elicited no comments. Likert Scale responses indicate that the amount of work was appropriate. Fifty-six and a half percent of the students rated this item at 3 while 21.7% thought there was too much work and 21.7% felt there was not enough.

There was little reading in the course so it is interesting to see that 21.7% of the students responded that the assigned reading was difficult. Students said, "We didn't read much, but when we did it was hard."or "Not much reading, but when it was hard he helped us." Most students used the comments section following this question to vent their frustrations over not having a textbook or worksheets. Many students said "Get a textbook.", "Get a text of some sort.", "Use a text that explains things well.", "Make (compile) a mastery textbook for teacher and student." and "Have more worksheets pertaining to what your learning and writing in your lab book."

Question 7 asked about test fairness and question 12, " To what extend did the exams tend to test intelligence or general academic ability rather than knowledge or amount of preparation?" elicited only negative comments with 36.2% for the former and 28.4 % for the latter holding strongly negative views. Comments for question 7 were that "His tests are too hard.","The tests are too difficult.", "Impossible testing.", "They are impossible.", "Quite hard and demanding.". One student recommended "Cut the testing in half." and another said "He usually has to work something out because kids bomb them

[tests]." That is to say the teacher had to adjust or curve the grades. Another student recommended "Cut testing by half."

Another source of dissatisfaction was the problem solving nature of the tests. Students were uncomfortable because they couldn't memorize and be successful on the tests. Their comments after question 12 revealed their frustrations. They said:

> Often tests on stuff we didn't learn. Test us on what we learn, not what we're expected to know or draw a conclusion. He spends so much time on one thing that in order to stay on schedule he spends little time on other areas but still tests you on them such as hypotheses. Some questions on the tests we never went over except maybe 5 minutes before it.

Yet despite the dissatisfaction with the tests most students indicated that the grades were fair. Only 2.8% of the students gave negative responses to this question. This contradictory response can be explained by looking at test grades. Most student did reasonably well and expected to get a B+ in the class. The dissatisfaction over the tests clearly results from the nautre of the tests.

Question number 9, " How much did you like the content of this course?" received the lovest number of positive responses; 19.5%. Comments were short and to the point. Students said "Drop it, it was dumb.", "Drop it or change content.", "bad topics.","Different subjects.", "More interesting topics.","Make it more interesting." More extensive comments were quite hostile such as "Make more interesting by doing more things than sitting down looking at the sloppy words on the blackboard."

Part of the problem seems to be that the students did not find the material applicable to real life (question 13). Forty percent of the students felt this way. They said:

> We are never going to use the material we learned. I thought this class was a waste of time. I didn't get anything out of this class. I'm sure I will not be observing a pendulum for a living and making tiny bucks an hour like some science teacher. I won't mention names.

In addition there were many negative comments about specific aspects of the course such as "Not so much math.", " not so many entries in our notebooks", and "I liked least graphing." as well as global dissatisfaction as indicated by the following comments. "This class sort of stunk."and "I just didn't like the class and didn't learn much."

On the other hand almost 43% of the students felt strongly that they were in a conducive learning environment, the material was covered adequately (44%) and that they liked the teaching methods (53.3%). Students commented that they "Liked lab work." and "Liked the dangerous experiments that get you excited." This suggests that the students enjoyed using materials and scientific equipment even if they disliked having to analyze, draw conclusions, and create hypotheses from the data collected. An examination of the means for questions 16 and 17, school GPA and expected course grade indicates that students had a B+ average in school and expected to get a B+ in the class. Lastly the students were asked to rate the course overall. The results indicate that 31.8% held strongly positive feelings, 28.6% held strongly negative feelings and 39.7% were neutral.

OPEN ENDED QUESTIONS

The responses to the open ended questions provided additional insight into the attitude decline associated with this course. Those comments relating to the course and teacher can be grouped into three categories each: (a) explain more or the course is confusing, (b) the course is moving too fast, (c) the course is too hard and (d) teacher temper, (e) teacher/student frustration, (f) teacher preparation and knowledge.

Explain More/Confusing

This category contained over 35 comments directing the teacher to explain things better or that the course or explanations were confusing. Students said:

> Doesn't explain things well. Explains things a bit confusingly. Needs to explain more. Make sure we know what we're doing before the next section. We usually don't know what we're doing. I don't understand about half of this class. Explain more. Explain better. Explain in simpler terms. Explain the material in more detail. Well he kind of explains things (a little bit) in a confusing way.

The Course is Moving Too Fast

This category contained a similar number of responses. Representative comments were:

> Try not to do so much in so little time. Give the students more time to get things done. Go slower in different subjects. Slow down on what your teaching. Spend more time. Sometimes he teaches too fast and doesn't get the lessons taught. Stick more to one topic. It usually seems like we switch topics unexpectedly.

One student suggested a tracking system he/she said "Have 3 sci lit classes and put the slow ones in one, the medium people in another and the smart ones in the last one - to insure that no one feels lost in the class." It is not known into which category this student would place him/her self.

The Course is Too Hard

This category also elicited many responses. Students said:

He talks on a college level so sometimes it's hard to understand him.

Teaches too complicated to dwell on. Some of it is so unobvious that no one can understand. This course is a good idea. It just needs to be simplified to the level of the students. If you have not had any science before this course is frightening. This class was real tough. I think I couldn't comprehend much of the stuff you taught. Even though this class might be important it went way over my head. Skip detailed lecture and work on the basics. We usually don't do well its too hard.

Teacher Temper

Open ended responses to the teacher were strongly dichotomized. Responses fell into the highly negative or highly positive category with no response indicating neutral emotions. The attitude decline seen for the course may be a reflection of the fact that about a quarter of the students disliked the teacher intensely. The majority of negative comments mention the teacher's temper. When referring to the teacher's temper the students said " His temper gets away with him sometimes.", "Short tempered.", "Small temperature span.","Hot headed. looses his temper." In rather revealing comments two students said "Has a short temper for us freshman.","Better temper control so he doesn't upset students."

Teacher/Student Frustration

Both the students and the teacher seem frustrated learning and teaching simple material. Student comments were:

> If you do explain, you get mad if we ask again. Sometimes he gets upset when we ask questions. Gets frustrated when students do not understand. Don't get mad if kids ask you to explain again. He yells a lot when you don't understand something. He should answer questions without yelling. Makes you feel really stupid. Assumes we don't know anything. For him to be less patronizing and remain equal with students.

On the opposite end of the spectrum, students who rated the teacher highly positive found him to be "warm", "Cool", "..can be humorous and make boring things interesting." They also had a different view of his relationship with the class. They said:

> Most of the students respect him. He makes us feel comfortable. He's easy to get along with. Warm, understanding. Works well with people. Relates to kids pretty well. Sticks with students. He cares. If we all did bad on tests he makes the grades easier.

This group found the teacher to be very helpful in explaining difficult ideas and helping students to learn. The students said:

> He helps until you know. [He] works on something until everyone has it. This instructor is very good with student needs. Always goes the speed the class goes not how fast he wants to go. He answers questions and makes sure kids know everything he teaches.

It appears that the student's perception of the teacher's classroom style depends upon whether or not he/she is grasping the material being presented.

Preparation and Knowledge

Despite the negative comments about the teacher's temper there was not a single comment that suggested that the teacher was not well prepared, knowledgeable in the subject or a good teacher. Students said, "He is very intelligent and knows what he is talking about.","Knows everything on the subject he is teaching."

They saw him as "..always well prepared for class." He "Tries to do the best job he can." and is "Eager to teach."

DISCUSSION

Factors Unrelated to a Decline in Attitude

A number of factors can be eliminated in the search for the reasons behind the decline in attittude observed at the end of the literacy course. Students were not upset about the grades they expected to receive in this class. Most students expected to get a B+, the same as their overall GPA. This is certainly a respectable grade for science and their overall GPA indicates that their academic performance was no different in other classes such as English or Social Studies. The students also thought that the grades they'd received throughout the year were fair. Therefore grades and grading practices can be eliminated from the list of posible influences.

Most of the students did not feel that the class too much work. So, we can also eliminate excessive homework, projects, and the like as a major factor in the decline in attitude towards science.

The students liked the teaching methods, which were varied to include lecture, media, and projects, with the greatest proportion of the

instructional time devoted to laboratory work and they felt that they were in a conducive learning environment. Most students also said that they had a good teacher, despite his temper. They felt that he was well organized, well prepared and extremely knowledgeable in science. This suggests that we can eliminate lack of teacher knowledge in content and pedagogy as well as the learning environment as a source for the decline in attitude toward science.

Factors Related to a Decline in Attitude

What remains is a sense of boredom, confusion, frustration, anger, and fear on the part of students. Students said that the class was boring, the topics were not interesting, and the course as a whole was not applicable to their life. This occurred in spite of the fact that activities were chosen by seasoned teachers, familiar with this age group, to be as interesting as possible to 9th grade students.

There was also a great deal of confusion because the students didn't understand the objectives of the course. The notion of literacy skills and problem solving in science was difficult to understand for students whose earlier academic career had been more traditional; listening to lectures, memorizing facts, and reading textbooks. One student put it very succinctly when he/she said "It was a very different class and it took a long [time] to relate." This may have also contributed to the belief that the class was not applicable to their lives . As another student said in a rather hostile comment "I'm sure I won't be observing a pendulum for a living and making tiny bucks an hour like some science teacher." Despite the teacher's effort to try to relate literacy skills to subsequent science courses and general life

skills he was not successful in moving the students beyond the immediate task of observing the pendulum.

Most of the frustration and anger stemmed from the skills, problem solving orientation of the class. The old ways of being successful in school, read the text, listen to lectures, take notes, memorize everything, and then recall it for the test, did not work in this class. So even though the students liked the physical interaction with science materials as indicated by their satisfaction with the teaching methods and comments such as "More experiments (danger)." and "More experiments in the lab." they resisted the cognitive demands of the problem solving approach. Many students suggested that the teacher get a textbook and some worksheets. This was I think partly because they were used to that style of learning and it was comfortable and partly because they felt it would tell them what they should know, i.e. memorize. One student said "Use a text that explains things well.". Another said "Have more worksheets pertaining to what your learning and writing in your lab book." This lab book, unlike many text accompanying lab books, consisted of blank pages.

When students did have reading assignments they found them to be very difficult. The readings were selected from various sources including newspapers and science magazines. Being non-textbook in nature they lacked the hints and prompts that guide a student's reading such as bold headings, pictures, and chapter end questions. In addition the ideas encountered in the readings were too difficult for many students.

Material difficulty was a source of continual frustration for the students. They commented frequently that the teacher should explain more,

because the material was confusing and to slow down because the pace was too fast. These comments are disturbing in light of the content and processes chosen and the total number of new content and processes introduced to the students. All the instructional material was selected from elementary school curricula such as Science: A Process Approach, Science Curriculum Improvement Study and Elementary Science Study. The course consisted of 5 units of study covering 16 topics and processes. Although this seemed a bit ambitious at the time, no one involved with the study expected the students to cover so few processes or to move as slowly through the material as they did. Despite the students' perceptions of speedind through the material it took an entire year to work with observing, inferring, classifying, measuring and seriation skills. They completed only a third of the material developed for the course, engaging in activities commonly found in elementary curricula, which were for the most part at the concrete operational level as judged by Piagetian theory. However, the students were correct in their assessment of the course as harder than anything they had encountered before because the criteria for learning was transfer and application, not memorization.

The students were also frustrated and angry with the tests. When asked if they thought the tests assessed what they studied or their IQ many students thought the tests assessed IQ. As one student said "Test us on what we learn, not what we're expected to know or draw a conclusion." In a sense the students were right about the tests, because they were problems to be solved, or a new context in which to apply a previously learned skill. Students could not be successful by memorizing an algorithm and some problems such as those involving classification did assess abilities that ranged from concrete to

transitional thought. This made the testing difficult for the students over and above the fact that their prior test taking skills and expectations were limited to memorizing facts and recognizing them on multiple choice tests. In addition, because of the research component of the course, students were constantly tested for skills acquisition and for personality, attitudinal and cognitive changes. This led to many general complaints about the frequency and number of tests. In this regard the research design may have been a contributing factor in the decline in attitude.

The difficulty of the material also had an effect on the way some students viewed the teacher. Students who expressed frustration over learning the material or feeling stupid also felt that the teacher was not being patient enough with them. They felt that he yelled at them when ever they asked questions. These students said "[He] gets angry if you don't understand." and "Blows up too easily and sometimes doesn't give you a chance." or "He doesn't have the patience to explain it when we don't understand something." These same students also felt that when the teacher did give explanations they were unsatisfactory. One student said "After you give assignments you don't really explain." Another said that the teacher's main weakness was "Not being able to get the point of the lesson across very well. Didn't explain things to us very well."

This is in marked contrast to the way in which the successful students perceived the teacher. These students saw the teacher as someone who "Helps you understand the subject fully." and "Gives everybody a chance to learn." A real fan of the teacher and the course said "Everything seemed to go

perfectly, if a student had a problem you were always there to help. I think your great."

A final factor in the decline in attitude toward science was fear. Many students were intimidated by the style of the teacher, the style of the course, and the criteria for success, as well as a general fear stemming from a lack of prior science instruction. Students said:

> When he yells he scares me away from science so that I don't like it anymore. If you don't understand something he scares you to death until you do. Better temper control so he doesn't upset the students. He doesn't care when he upsets someone to the point of tears. If you have not had any science before, this class is frightening. This class was real rough.

The School Attitude Measure

If we now examine the scales on the School Attitude Measure (Wick & Smith, 1980) the reasons for the decline in attitude become even clearer. It is important to keep in mind that the students responded to these scales only as they related to their experiences with science and the science literacy course.

Motivation measures:

willingness to participate in current school experience because it is meaningful.

desire to perform competently in future school experience.

perception of the relationship of current schooling to future needs.

willingness to pursue further schooling.

perception of the importance of schooling relative to other activities.

perception of the way individuals significant to the student view the student's school experience. (Wick & Smith, 1980, p. 8)

Student ratings and comments indicate that they saw little relationship between their current schooling in science and any future need, nor did they find it particularly meaningful. In addition the perception of a very significant individual, the teacher, of the student's school experience was not very positive for many students. Thus it is not surprising that student motivation declined as a result of the literacy course.

Self-concept - 1, performance based self-concept measures:

perception of his/her ability to do the majority of school tasks competently.

feeling of importance as a member of his/her class.

reaction to poor performance.

expectation of success.

involvement vs. withdraval in school tasks.

confidence in his/her own efforts. (Wick & Smith, 1980, p.8)

The students clearly did not have the perception of their ability to do the majority of the science tasks competently because they frequently mentioned their poor performance and the difficulty of the class. They also had little confidence in their own efforts to be successful on the tests as many felt that the tests did not assess effort or learning, but IQ. Many student reacted with anger and frustration.

Self-concept - 2, referenced based self-concept, did not decline. A possible explanation lies in the central construct of the scale: "comparison

of current performance with appropriate reference groups. (Wick & Smith, 1980, p.8). Since the entire Freshman class at the high school was taking the literacy course and experiencing the same problems and frustrations a discrepancy between the student and his/her reference group did not exist.

The Control scale measures a sense of control over performance and is based on the Locus of Control construct. As such it includes:

> perception of ability as opposed to luck.
>
> willingness to take responsibility for school outcomes.
>
> awareness of the relationship between actions and outcomes of schooling.
>
> self-reliance and independence in the school setting. (Wick & Smith, 1980, p.8)

Many students did not see themselves in charge of their own success or failure in this course. They blamed the teacher for their problems saying he didn't explain well or answer their questions, moved through the material too quickly and didn't make it interesting. Poor performance was also blamed on the fact that they didn't have a textbook and that the tests didn't test what they learned, but their IQ.

The last scale, Mastery, measured the student's instructional mastery in the following way:

> ability to use school time effectively and efficiently.
>
> ability to focus attention or concentrate on instructional tasks.
>
> ability to seek and use feedback (criticism, advice, and help from others).
>
> ability to evaluate his/her own work. (Wick & Smith, 1980, p.8)

The novelty of the problem solving nature of this class made the application of these mastery skills very difficult for many students. Effective and efficient use of time seems to have been a problem. Students frequently said that they didn't have enough time to learn. They felt this way in spite of the fact that in absolute terms very little of the planned curriculum was taught. Most students didn't understand the objectives of the class and many were confused or did not understand the nature of their tasks. As a consequence few students could be said to have the ability to focus attention or concentrate on instructional tasks.

Evaluating their own work was also difficult for students. Since the course focused on the acquisition of literacy skills and the application of these skills to problems there was always more than one solution to any assignment or test. This left many students unsure of the quality of their work and the correctness of their solutions. In many cases the teacher never gave an absolute right or wrong evaluation of student work, but based his evaluation on the degree to which a problem had been solved elegantly, creatively or efficiently.

In conclusion, the problem solving nature of the class, learning to think, and to a lesser extent the perception on the part of students that the course had no real life applications contributed to the decline in attitude which resulted from participation in the scientific literacy course.

This raises some unsettling questions for science educators. What should science instruction look like if, as this research and the work of others indicate, problem solving leads to poor attitudes, confuses students and they can not read inquiry materials (Costenson & Lawson, 1986; Welch, Klopfer,

Aikenhead & James, 1981)? Why do students resist learning to think? Why, despite our best efforts, do students see science as boring and unrelated to their lives? Are we expecting too much from average students? Should we go back to a nature study approach in order promote positive attitudes toward science and impart some knowledge about the natural world? Should an analytical approach to learning science be reserved for an elite group of students who enjoy solving problems?

Democratic values and a society that is becoming increasingly technological demand that the response to the questions I have raised is that we need a better understanding of what students like about science and how they learn science. Curriculum development must focus on new ways of teaching problem solving so that it is an enjoyable experience for both teachers and students. Clearly, further research is required that will lead to a reconceptualization of science instruction.

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Table 1

Changes in Cognitive Ability and Attitude Toward Science

	MEAN SCORE			
SCIENTIFIC LITERACY	pretest	posttest	t-value	2-tailed P
Observation	7.8	43.3	-23.9	0.00
Inference	5.5	18.4	-38.9	0.00
Measurement	2.3	8.8	-19.7	0.00
Classification	27.1	27.1	-0.4	0.71
Seriation	3.3	117.3	-33.6	0.00
Total	40.2	117.3	-26.6	0.00
COGNITIVE ABILITY				
Verbal	17.4	19.5	-6.8	0.00
Quantitative	13.2	15.8	-8.1	0.00
Spatial	10.3	12.9	-7.8	0.00
Total	40.4	47.8	-10.4	0.00
ATTITUDE				
Motivation	62.3	58.9	6.1	0.00
Self-concept 1	55.8	54.1	3.4	0.00
Self-concept 2	54.0	53.0	1.9	0.06
Control	64.4	61.0	6.2	0.00
Mastery	58.0	54.8	6.5	0.00

Table 2

Evaluation Instrument Questions

1. Did he stimulate thinking?
2. Did he present put the material across in an interesting way?
3. Considering everything how would you rate this teacher?
4. Were the course objectives clear?
5. Was the amount of work required appropriate for the credit received?
6. Was the reading assigned difficult?
7. Were the tests fair?
8. Were the grades assigned fairly?
9. How much did you like the content of this course?
10. Did the material cover the subject adequately?
11. Did you feel you were in a conducive learning environment?
12. To what extent did the exams test intelligence or general academic ability rather than knowledge or amount of preparation?
13. How applicable was this course to real life?
14. How would you rate the instructor's teaching methods?
15. How would you rate this class overall?
16. What grade do you expect in this class?
17. What is your overall GPA?
18. What are your teacher's strengths?
19. What are your teacher's weaknesses?
20. What suggestions do you have to improve or enhance this class?

Table 3

Means and Standard Deviations for Likert Scale Items on the Evaluation Instrument

Variable	Mean	Standard Deviation
Q1	3.89	1.09
Q2	3.37	1.29
Q3	3.40	1.02
Q4	3.27	1.28
Q5	3.03	.73
Q6	3.08	1.10
Q7	3.06	1.26
Q8	3.97	.91
Q9	2.74	.95
Q10	3.16	1.12
Q11	3.48	1.03
Q12	2.96	1.0
Q13	2.84	1.01
Q14	3.47	1.05
Q15	3.03	1.20

Table 4

Frequency Distribution of Negative, Neutral and Positive Ratings by Percentage

	Negative	Neutral	Positive
	Ratings 1 - 2	Ratings 3	Ratings 4 - 5
Q1	13.2	14.5	72.3
Q2	21.9	28.0	50.0
Q3	22.9	29.3	48.7
Q4	27.9	29.4	42.7
Q5	21.7	29.3	21.7
Q6	25.4	42.9	31.7
Q7	36.2	26.1	37.6
Q8	2.8	29.0	68.1
Q9	37.7	42.9	19.5
Q10	28.3	26.7	44.0
Q11	15.6	41.6	42.9
Q12	28.4	45.9	25.7
Q13	40.0	28.0	32.0
Q14	4.3	32.5	53.3
Q15	28.6	39.7	31.8